FOSS® Magnetism and Electricity
Teacher Preparation Video Transcript

<Larry Lowery Introduction to FOSS Program>

Lowery: Hello. Welcome to the Full Option Science System. This program was funded by the National Science Foundation. Its goal was to develop materials that would involve youngsters with both the processes and the content of science.

The program is developed with the Lawrence Hall of Science, with scientists, science educators, and teachers working together as a team to develop the materials. The materials are tested in the hands of teachers and children in classrooms. It takes about two years to turn out a module.

Each module begins with firsthand experiences. This is done because it has been found that firsthand experiences are the best way for youngsters to learn about the concepts of science. As module progresses, children are introduced to abstractions and reading materials. The sequence from firsthand experiences through reading materials is deliberate because it has been found that youngsters, when they have some experience before they read, learn and understand more from the reading. Authors of reading materials can then take youngsters to greater abstractions.

Trust the materials that you are getting acquainted with. They have been well tested. We found that they work extremely well in the hands of all teachers, and are effective for youngsters in learning about science.

<Larry Lowery Introduction to Magnetism and Electricity>

Magnetism and electricity are part of our everyday lives. Magnets can be found in television sets and telephones. Electricity runs our appliances. We turn lights on at night so that we can see in the dark, thanks to electricity. Magnetism and electricity are important for students to learn about because they are so much a part of modern technology.

From the investigations in this module, students will learn about the characteristics of magnets. They will also learn to develop initial ideas about the flow of electricity. Students cannot actually see electricity traveling through the wires in a circuit. Instead, they must draw the conclusions about what is happening from some sort of evidence, such as a light going on or a motor running.

<Kathy Long Introduction to Module>

Narrator/Kathy Long: Hi, I am Kathy Long and I am here to help you get started with the fast magnetism in electricity modules. This module consists of five investigations. Each investigation is designed to introduce students to important ideas about magnetism and electricity and the relationship between the two.

Most of the equipment comes packaged in a kit. Everything you see here comes in these two boxes. There is enough equipment packaged in a kit for a class of 32 students. You'll need to check the inventory sheet in the materials folio so you will know which materials are consumables and which are permanent equipment.

For one activity, you will need the balances from the FOSS Measurement kit. The balances are specially designed with this little well in the base for that particular activity.

You will need to supply a brown paper bag, three index cards, a meter tape for measuring and cutting the wire, pencils, transparent and masking tape and some old wire that you find lying around in a junk drawer or that may be the custodian can help you find.

Before you began teaching, it is important to look through the entire teacher's guide. First, you will find the Overview folio, which points out the national standards addressed in this module as well as information about how to make best use of the teacher guide. It also includes valuable background information specially written for teachers who have not had extensive science training.

Next, you will find the Materials folio. If you are the first teacher using a new kit, you want to turn to the section that describes first time prep. If the kit has been used before, check the section with directions for each classroom use. Both of these sections will give you helpful hints that will save you lots of prep time later.

The next five folios are the Investigation folios. These are the heart of the program. Each takes one or two weeks to complete. The first page provides the overview information. The at-a-glance chart summarizes the investigations and helps you plan for assessment and extension activities.

Next, you will find background informations specific to this investigation. The section called "Teaching Children About" gives you some insight into research about how children think and learn.

Then for each part of the investigation, you find the materials list, getting-ready section, and step-by-step instructions for how to proceed through the investigation. At the end of the folio, you will find interdisciplinary extensions. You can do some of these extensions with the class or save them for students to use as projects at the end of the module.

Next are the Investigation Duplications Masters. Each master is labeled with a number, so it will be easy to find when you need it. Shortly before beginning this module, copy the letter to parents and send it home with the students. The letter tells parents about the module, and suggests some activities they can do at home together.

It is important to read the Assessment folio before you begin teaching. It describes the system for assessing students throughout the investigations and also gives you ideas for end-of-the module testing or portfolio assembling. The folio contains scoring-guides for each of the assessments suggested.

Next are the Assessment Duplication Masters. Here you will find all the masters for the assessment charts and end-of-the module assessments.

The Science Stories folio provides background information, recommends when to read these stories, and provides follow-up activities. You may want to read the science stories during a reading period rather than science time, especially if you only teach science a few times a week.

The next folio is the Resources folio. In it, you will find less of trade books, videos, computer soft ware, and other resources that support the program.

The final section introduces you to the FOSS Website. On the website, you will find simulation for each module in the program. Students can contact scientists and other FOSS students across the country. You will need to check the website to see the many feature available there, including resources for teachers.

If you are the first teacher to use the kit, here is how you do the first-time prep. First, you take out the eight bags of test objects, make two copies of the inventory sheets, cut them apart, and place one on each bag. This will enable students to inventory the bag each time it is used.

The kit contains two sizes of wire, 20-gauge, which is the red wire, and 24-gauge, which is the yellow wire and thinner than the red. From the spool of red wire, you will need 16 pieces 30 cm long and 32 pieces 15 cm long for the students to use in investigations. They will also need 16 pieces, 7 cm long to make the mystery boards, which I will be showing how to make. You will need to cut 8 pieces of yellow wire 150 cm long. To keep the wires from getting tangled, wrap them around your fingers, and give them a twist like this to make a figure 8.

Here is how you use the wire stripper. First, be sure to remove the storage clip, and then you can cut the wire like this. To remove the insulation, you will need to set the gauge, then clamp the stripper on the wire and pull the insulation off without cutting wire.

There are 9 motors in the kit. The rotation of the motor will be easier for the students to see if you put a little masking tape flag on the stem like this.

Here is how you make the mystery boards. Find the eight cardboard pieces in the kit and fold them with the white side out. Insert a paper fastener to each of the holes from the white side. Once you've got all the paper fasteners in the board, label each board A, B, C, D, and give each board a number 1 through 8. You will use the mystery board design sheet to help you wire each of the mystery boards.

So, here is diagram number 1, and you can see that I wired this mystery board to match the diagram. To attach the wires, you just need to wrap the un-insulated and of the wire around the each brass fastener, and then leave the legs of the brass fasteners flat against the cardboard. For extra security, you can put a piece of masking tape over of each of the connections. Once you get the wires attached, you close the cardboard flat and then tape each of the open sides with masking tape. That way the students won't be able to see the wiring inside.

Here is how to prep the iron filings so that the students can use them safely. Take one of the little plastic spoons out of the test object bags and use it to put the iron filings on a plate. Be sure not use more than one level spoonful. Put the plate into a zip bag, and seal it shut. You might also want to put some transparent tape along this edge to seal them permanently. Now students can use a magnet and see how it interacts with the iron filings. They will also be able to use the iron filings again and again.

The final thing to get ready in the kit is the magnet detecting boxes. Fold each one up into a box, label the upper left-hand corner with a number like this. Label the boxes 1 through 8.

Prepping the kit as I have shown you here means you have very little to do before each investigation. Now you're ready for the fun and learning.

<Investigation 1, Part 1>
Narrator: In Part 1, as students begin to investigate magnets they will find out what materials stick to magnets and what happens when two or more magnets are brought together. Before you begin each part, you will need to set up a materials station.

Here is what you will need from the kit for Part 1: magnets and bags of test objects. You will need to supply paper, pencils, and a brown paper bag.

You will need to make copies of these Duplication Masters—number 2, called "Magnetic Observations" and the assessment chart for Investigation 1.

On large chart paper you will want to make a word bank. This is where you will keep all the new vocabulary as it appears throughout the module. Also, you'll make a Content Inquiry chart. Here is where you will write statements that summarize what the students have learned. It is also a good place to keep the questions that the students still have.

You will also need to make a project folder. As students think of ideas during the investigations for projects, they will write them down and keep them here so that you will have them handy for the end of the module. The last thing that you need to do to prep for this part is to put a magnet inside the large paper bag.

This part begins with a game called "Describe the Object." You will invite a student to put his or her arm into the bag and yield the object and describe it for the class. They might use words like it is small but it is heavy, it is round and it has a hole in it. When the student runs out of descriptive words, then you will ask the other students to ask questions. When their questions run out, then you will have them draw a picture of the object on a piece of paper. When they finish their drawings, you will take the magnet out of the bag and have them compare the drawings to the object. The point of doing this game is to help students become better at giving detailed descriptions and also to ask questions that help them find out information they need.

Next, each student is handed one of these objects to examine more closely. You want to do this, so students don't notice them sticking to each other. Students investigate what the object can do.

Some students observe that it can roll, other students discover that it can stick to things. The teacher confirms that an object that behaves this way is called a magnet. Students tell the teacher what they already know about magnets. They then see what their magnet will stick to right around their desks.

Teacher: You are going to stay in your seat, but you are going to test things in your area. Find out what this magnet can do.

Narrator: When students report their findings, there should be a general agreement that magnets stick to metal objects. But do they stick to all metal objects?

The starters collect all four magnets and place them inside their desk. Getter gets one bag of test objects. The starter spreads all the items on the desk and the whole group divides the objects into two groups so that each pair has one of each item. Students work up with a partner to source the object into two piles. Things that they predict will stick to a magnet and things that they predict will not stick.

Student: This will stick for sure.

Student: That will never stick.

Teacher: In a minute, I am going to have you take out your magnet off your chair leg and you are going to test the objects and when you test them you will put them in the piles of the things that stuck to the magnet and the things that did not stick to the magnet, in two separate piles. Okay, does everyone understand?

Students: Yes.

Teacher: Okay, why don't you quietly take out your magnet and start working.

Student: That doesn't stick.

Student: This one doesn't stick.

Teacher: We just finished testing the objects of a magnet. I would like you to think about your prediction. Raise your hand if you can tell me if there is anything that surprised you that something stuck that you didn't think would stick. Okay, Ty.

Student: I was surprised that the nail did not stick.

Teacher: Okay, which did, neither nail stuck or …….?

Student: No, one of the nails did stick but the other one didn't.

Teacher: Michelle.

Student: I was surprised that this rock stuck.

Teacher: Okay, why are you surprised that it stuck?

Student: Because it did not look like metal and so, and then I tried and it stuck.

Teacher: Okay, Alex Steve.

Student: I was surprised that it did not stick?

Teacher: Why were you surprised that it did not stick?

Student: Because this sort of looks like a copper.

Teacher: Ok, and you are expecting that to stick. Ok.

Narrator: Students may be surprised to find out that one of the nails does not stick and neither does the brass ring. They are both metal but they don't stick. They also may be surprised to find that one of the rocks does stick. This is a special kind of mineral called magnetite and it has a very high iron content. Students will read about how this mineral got its name in the FOSS Science Stories.

Now that you have established that magnets only stick to iron, students use the magnets as iron detectors to check the classroom out for things that are made of iron or steel. Be sure to place off limit signs on computers, televisions, and other things that could be damaged by magnets. Each student has a magnet and a student sheet and can work individually or with a partner on this challenge.

If you are planning to do this part in two sessions, this is a good place to stop. When you are ready to continue, students will find out what happens when two magnets interact.

When students have had enough time to explore the interactions with magnets, you'll introduce some new vocabulary. Key words for this part include magnet, force, attract, and repel.

Teacher: Okay, we are going to start another part of what we have learned.

Narrator: You begin the Content Inquiry chart by listing statements that summarize what the students learned from the investigation. Be sure to ask students to contribute questions they still need answered.

This is also a good time to introduce the students to the project folder. Whenever they have an idea, they would like to contribute they should write it down and put it in a folder. Students will use these ideas at the end of the module when they decide what they would like to do for their final projects.

The important things for students to take away from this part are that magnets only stick to iron and that there is a magnetic force responsible for this action and that when two magnets come together, they either attract or repel.

<Investigation 1, Part 2>

Narrator: In part 2 of this investigation, students will find that a piece of iron or steel can be made into a temporary magnet when in contact with a permanent magnet. They will also find out that the force of magnetism goes through many materials.

Here is what you will need from the kit. You will need the permanent magnets and the eight bags of test objects. You will need the permanent magnets, and the eight bags of test objects. You will need to supply scratch paper, pencils, and a large paper clip.

You will need to make copies of this Duplication Master: number 4 "Response Sheet—Magnets. Be sure to have the assessment chart for investigation 1 on hand as well.

This lesson begins with a review from Part 1 about permanent magnets. Then you will pose two questions. How do iron objects and magnets interact together? And does the force of magnetism go through other materials? You may see the students begin to use more than two magnets together.

The students will find that magnetism will travel through one object to another.

You will want to allow plenty of time for exploration.

The things to focus on in this part are that when a piece of iron or steel come in contact with a permanent magnet, they become a temporary magnet. This kind of magnetism is called induced magnetism. Students should also know now that the force of magnetism can act through many materials.

<Investigation 1, Part 3>

Narrator: In Part 3, "Breaking the Force," students will use a balance and washers to measure the force of attraction between two magnets.

You will need these materials from the kit: eight of the doughnut magnets, the magnets on a post, the plastic spacers, the sticky dots, and you will need to cut those into strips of seven dots each, and you will need the eight bags of large washers. From the Measurement kit, you will need the balances and cups.

You will need to make copies of the Duplication Master number 5, called "The Force." Also, you will need assessment chart for Investigation 1 handy.

If you have not used the balance before, you may want to practice assembling it. Put the magnet on a post in the well on the base. Then, you will put the balance beam on the fulcrum and a cup on each side. Finally, you will put the loose magnet in the cup above the magnet on the post. Now, you're ready to begin.

You will begin this part by asking a question: Can you find a way to measure the force of attraction between two magnets? The students need several minutes to come up with the procedure that will enable them to find the answers to the question. You may give students who are having trouble getting started, the hint that the magnet on the post can be inserted in a little well on the balance base. If students are trying to pick up the washers with two magnets, you may need to remind them that their challenge is not to find out how strong two magnets are together, but how much force is needed to pull them apart.

The teacher monitors class progress and as groups develop successful systems as you see here, she calls on them to share their ideas with the rest of the class. Notice that when the force is first broken, students are able to re-establish the connection.

This may be a good point to take a break. When you continue this investigation, the new challenge will be for students to work systematically, moving the magnets further and further apart to find out what happens to the force between them.

Here is what to look for. It does make a difference where you stack the washers. If you put them in the cup further away from the fulcrum or closer. Also, if you stack the washers versus put them in at random. When the force appears to be broken, the balance should always be reset to make sure. Here you can see that more washers can be added before the force is truly broken.

Teacher: Now, what we are going to do is we are going to find out what happens to the force of attraction between two magnets when you move them further apart. Do you think this force will get stronger, weaker, or do you think it might stay the same? Now, what I am going to do is I am going to come around and give each of you a spacer like a little poker check.

Narrator: Small plastic spacers are used to increase the distance between the two magnets.

To compare the results of a scientific test, it is important to do every test the same way. The teacher explains that each group must follow the same procedure for each trial.

Teacher: So, now you have a space between them.

Student: Let's find out. That's 1…

Narrator: The teacher assesses students to see that they are working systematically, using the same technique for each trial. Do the students place the washers gently in the cup and use the same arrangement each time? Do they reset the balance each time the force is broken as a check?

Students make a T chart to record the results of their investigation. One column is for the number of spacers used and the other for the number of washers it took to break the force.

As students work on the investigation, have students skip testing two spacers so they can use the graph they make later to predict the number of washers needed to break the force when two spacers are used. When the students are finished investigating, their T chart should look something like this.

Each student needs seven adhesive dots, and "The Force" sheet to record their data. If students have not had much experience with graphing, they will need a detailed demonstration of how to transfer the information on a chart to the graph.

To complete the graphs, students will need to label the axes first. You will write spacers on the horizontal axis and washers on the vertical axis. Then you will need to number both.

To mark the data points, you will need to put a sticky dot where two lines intersect. Once the graph is completed, students can use it to make a prediction for two spacers and then test to see if their prediction is correct.

Student: I think you touched it.

Student: No. Guess not.

Student: That was 3 washers…

Student: Put a dot on 5. Now we have to guess what 2 might be.

Student: I think it might be 8.

Student: Might be 7.

Student: Because this has a farther distance so it might be. Probably 7 or 8.

Student: I think it's 8.

Student: What do you think Jeffrey?

Student: Either 9 or 8. 8

Students: 1, 2, 3, 4… That's 4, 5, 6, 7, 8…

Student: You touched it…

Students: It's 8.

Narrator: At the end of this session, student should be able to look at their graphs and see a pattern. As the distance between two magnets increases, the force of attraction decreases.

<Investigation 1, Part 4>
Narrator: In Part 4, students will explore ways to detect the force of magnetism.

From the kit, you will need the 8 bags of test objects, the 8 boxes that you assembled during first-time prep, the compasses, the doughnut magnets, and the iron filings, which you also prepared during first-time prep, putting them on the plates and into the bags. You'll need to supply masking tape.

You'll need to make copies of these Duplication Masters: number 6, called "Detecting Magnets," and then be sure to have your assessment chart for Investigation 1 handy.

You may want to practice using the iron filings. The bags can be used in two ways. Students can place the plate of filings on top of the magnet and gently tap the plate until the filings fall in line with the magnetic field of the magnet. They can also move the magnet around underneath the plate and create magnetic art.

You might also want to try out a magnet box before using them with the students. Tape two magnets inside the box. You can put them together, or far apart, or even on top of each other. And then close the lid and practice detecting the magnet locations with the detecting tools. You might try some of the things from the test objects bag.

Ah, there I found the magnets.

You might try a compass. There we go.

Or, you may use the iron filings. Oh, that gives me a pretty good idea of where those magnets are.

To begin this investigation, you will want to review what students have learned by referring to the Content Inquiry charts. Then you'll introduce the magnet detecting boxes. Getters get the materials.

While one pair investigates the tool they will use to find the magnets, the other pair tapes the magnets in the box. Students need to be sure the other pair doesn't see where the magnets are being placed.

There are many interesting ways to arrange the magnets—far apart, close together, one on top of the other. Each different way produces a different effect with the detecting materials.

Before returning the boxes to the materials stations, the students should take the magnets out of them. But you should store the boxes assembled in the kit for the next class.

The two important things that students should get from this part are that the force of magnetism can go right through materials, in this case, the cardboard boxes, and that this invisible force called magnetism can be detected using objects made of iron or steel.

<Investigation 2, Part 1>
Narrator: Now we'll turn to a study of electricity. In the first part of this investigation, students will build very simple circuits, with a focus on where connections need to be made.

From the kit, you'll need the D-cells, the light bulbs, the short red wires that you prepared during the first-time prep. And keep the wire strippers handy just in case one of the wires breaks and you need to strip off some more insulation.

You'll need to make a copy of Duplication Master number 7, "Flow of Electricity" if you want to pre-assess student knowledge about the flow of electricity through a circuit. If you use this sheet, you can also have students complete it a second time near the end of the module to see how their ideas have changed. You'll also need to duplicate a copy of the assessment chart for Investigation 2.

Check the wires to make sure there is bare wire showing at each end, and be sure to remind students that the D-cells are safe to use, but wall sockets are not.

Teacher: Today our challenge is to see if we can get this D-cell to light up this light bulb.

Narrator: The teacher monitors students' progress as students try to find through trial and error a way to light the bulb. Holding wires to make contacts can by clumsy, but the teacher resists the temptation to show students what to do.

Student: Oh yes. We did it.

Student: I can't believe it. It works.

Teacher: Ok, I noticed you got it to work. Where did you have to have the wires touching to get it to work?

Student: From the plus sign to here.

Teacher: And where else? Where did you have to have it touching on the light bulb?

Student: Um, right here… and on the sides.

Teacher: And on the sides? You had to have it touching on both at the same time? Is that why… When it stopped working, what was the problem?

Student: It wasn't touching the side and the bottom.

Teacher: Ok, good.

Narrator: When all of the students have succeeded in lighting the bulb, reporters share their method for producing light. Students draw a picture of their circuit on the board. The teacher traces the path taken by the electricity from the end of the battery, to the tip of the bulb, through the bulb, out the silvery side of the bulb, and back to the battery. The teacher asks what shape she is drawing. The students say it is a circle, and then she introduces the word "circuit."

Teacher: Ok, our next challenge is, can you use the battery and one wire to light up your light bulb? Only using one wire this time.

Student: One's on the bottom.

Student: Remember how we did it with two? One had to touch the side and one had to touch the bottom?

Student: Oh, that's right. Maybe that's it.

Student: Cool. We did it.

Narrator: This is a good point to talk about what's inside the light bulb. When electricity runs through it, the filament gets so hot, it glows.

The most important thing students should learn from this lesson is that you have to have a complete circuit in order to get electricity to flow from the source to a receiver.

<Investigation 2, Part 2>
In this part, students use a circuit base to build circuits that include a D-cell, a motor, and a switch. They also learn the conventions for drawing schematic diagrams.

Here's what you'll need from the kit. You'll need the 8 circuit bases, the D-cells, the motors, the short red wires that you've already prepared, the switches, and the bulbs in the bulb holders. Once you've put them in the holders, you should keep them there for the rest of the module.

Make copies of these Duplication Masters: number 8, “Drawing and Schematics,” and number 9, “Response Sheet—Bulbs.”

To begin this part, students review circuits. Their challenge today is to get a motor to run.

Student: Jake, don’t you remember that the battery had to have one more on the plus and one more on the minus?

Student: Right here and here.

Student: We did it.

Student: We got it to go. Cool.

Teacher: Ok, you got your motor running. Can you now trace the flow of electricity for me?

Student: Here and then goes through the motor and then it goes through the wire and then goes to the battery.

Teacher: Right.

Narrator: In a few moments, all of the groups will have their motors running. Students should agree that one motor wire must touch each end of the battery to make it run.

Next you’ll show the students a circuit base. The D-cell goes into the holder and the motor goes on the circuit base. To hook the wires into the Fahnstock clips, you want to push down on the clip and insert the wire through the little loop, and then let go of the Fahnstock clip.

Be sure that students understand that the electricity needs a complete pathway from the source, to the receiver, and back to the receiver in order to run the motor.

Teacher: Ok, this is the switch, and the handle moves up and down. Your job today is to find out what does this switch do in a circuit?

Student: Wait, wait, wait…

Student: You got it. Yay!

Student: From the negative side to here. Then once this is closed it flows through there to there, then makes this work. And it goes back to here.

Teacher: So tell me, what does the switch do?

Student: It makes this close.

Teacher: Ok, so when the switch is open, it's not going to work?

Student: No.

Teacher: It only works when it's clicked on?

Students: Yah.

Teacher: Right. Ok, good. Let me go check another group.

Narrator: An important idea to develop here is the difference between an open circuit and a closed circuit. When the switch is open, there is no flow of electricity so the motor doesn't run. But when the switch is closed, electricity can flow through the circuit, and the motor runs.

Students apply what they've learned to new circuits that use a switch to turn a bulb on and off. Students draw the schematic for their circuit. You'll want to point out that schematics are always drawn with square corners to keep them neat.

Be sure to encourage student to be writing down their ideas and putting them in the project folder so they'll have them for the end of the module.

At the end this part, students should be able to build very simple circuits, and they should have a basic understanding of how they work.

<Investigation 2, Part 3>

In this part, students build circuits to test whether objects are conductors or insulators.

Here's what you'll need from the kit. You'll need the eight circuit bases, eight D-cells, the motors, the switches, the short red wires, and the bulbs in holders. Save the neck cords and the long red wires to put at the materials station later in the investigation.

You'll need to make copies of this Duplication Master: number 10, "Conductors and Insulators." You'll also need the assessment chart for Investigation 2, which you've already copied.

Let's go back to the classroom and see how this part begins.

Teacher: Using the nail and the straw, you're going to be testing these objects to figure out which one can complete a circuit.

Student: It worked

Student: Is there one more?

Student: It should work…

Student: Nope.

Students: The straw doesn't work.

Student: The nail works… and the straw works on the other thing.

Teacher: When an object allows electricity to flow through it, we call that a conductor. When an object prevents electricity from flowing through it, that is an insulator. Now you've tested two objects – a nail and a straw. Hold up the one that worked as a conductor. Hold up the object that worked as a conductor.

So I see you're all holding up the nail. And the nail… when you put the nail into your circuit, did the motor run?

Students: Yes.

Teacher: Ok. Which object worked as an insulator? The straw worked as an insulator. So when you put the straw in your circuit, did your motor run?

Students: No.

Teacher: No, because it stopped the flow of electricity. Ok, you each have a bag of test objects. In your group, you're going to predict which objects will work as a conductor and which objects will work as an insulator.

Narrator: Notice the students have removed the circuit boards from the work area while they make predictions.

Student: I think both of these will work.

Student: What about the nail?

Student: I don't think both of those will work

Teacher: Ok, so you're sorting which ones are conductors and which are insulators?

Student: Yes.

Teacher: Ok, can you show me which pile is which?

Student: This is the conductors. And this is the insulators

Teacher: Ok. Can you pick two items from each group and we can go ahead and test them? You'll do the straw? Have you already tested the straw? So maybe you should choose something you haven't tested.

Student: Ok, the rubber band.

Student: Yes, it works.

Student: The brass ring works, too.

Student: No, the rubber band didn't work.

Student: It works.

Narrator: Next, the students make a circuit they can use as a detector to take around the classroom and look for conductors.

Guide the students through this modification. Remove the short wire and have students trade it in for two long wires. Attach one long wire to the free end of the D-cell, and the other long wire to the free end of the switch. Close the switch so that it stays securely underneath the little bronze tab, and then test to make sure that you have a complete circuit. You'll tie the neck cord into the holes on the circuit base.

Be sure students follow two rules. If they want to test something on a person, they need to ask permission from that person. Wall sockets and switches are off limits. You may even want to put a piece of masking tape over wall sockets as an extra precaution.

The students attach a cord to the tester and hang it around their necks.

Student: Look at this – it works.

Student: Push it down, yes?

Student: Yes.

Student: Yep. The white pen holder does not conduct electricity.

Student: White pen holder is not a conductor, it's an insulator.

Student: Try this one.

Student: Ok, so what doesn't work?

Student: The pen does.

Student: Amy?

Student: The stapler works.

Student: Did we already write down that this works?

Student: Let's try your glasses.

Student: Ok.

Student: It works. Whoa.

Narrator: Students continue recording results on their student sheets. If a group tests a metal object that is painted, they may find the motor doesn't run because the paint is an insulator.

The important things for students to remember from this part are that materials that allow the flow of electricity through them are called conductors. Materials that don't allow the flow of electricity are called insulators.

<Investigation 2, Part 4>
This part of the performance assessment. Students will apply what they've learned so far. You can test students individually and have them work at stations or they can work with their groups.

Here's what you'll need from the kit, the D-cells, the long and short red wires, the switches, the mystery boards, the lights in the bulb holders, and the motors.

You'll need to make copies of these Duplication Masters: number 11 called "Mystery Circuits" and number 12, called "Making Connections." You'll also need your assessment chart for Investigation 2.

Student: Use the light, D-cell, switch, and wires to construct and..

Narrator: The directions on the student sheets were written so that after your initial instructions, students can read and complete the task on their own.

Student: And we're going to connect this left wire to the switch.

Student: Let's see if it works.

Student: Let there be light.

Student: Find the mystery board on the table. Show the paper fasteners on the mystery board are connected by hidden wires. Find out which paper fasteners are connected by wires.

Student: I'd say C, A

Student: No, C, B, C D.

Student: Yes. C, D.

Narrator: Students have to explain how the mystery board works on the student sheet.

Check the assessment folio for scoring guides for the two sheets students complete in this part. This assessment should give you a good idea about how your students are thinking about circuits and the flow of electricity through them. Don't forget to check the last few pages in the folio for interdisciplinary extensions.

<Investigation 3, Part 1>
In this part, students begin to learn how to build circuits with multiple bulbs, batteries, and motors.

Here's what you'll need from the kit. You'll need the eight circuit bases, the D-cells, the cell holders, the switches, the bulbs in the holders, the motors, and the long and short red wires.

You'll need to make copies of these Duplication Masters: number 15, called "Advanced Connections," and the assessment chart for Investigation 3.

Begin this part by reviewing what students know about circuits.

Teacher: Alright, now we've been working with circuits, and so today we have a challenge, and the challenge is, how can you make two lights light with only one D-cell? Now think about that, let's get the worksheets out and ready and you're going to draw on there, first what you're what you're going to do before the getters get any materials at all.

Student: We could take the D-cell, the light bulb, or the two light bulbs, and then the wires, and then connect one end of the wire to the D-cell, and the other end to one of the light bulbs. Then from the other side of the light bulb, we could attach the wire, which attaches to the other light bulb, and have another wire attach to that light bulb and go to the D-cell, so it runs in a circuit that way.

Narrator: When students have their plan in place, the getters get the materials, and students start to construct their series circuits.

Student: Only that one lights.

Student: Wait. These have to be turned off.

Narrator: Not all the circuits will work at first. The students may have to do some trouble-shooting to get the bulbs to light.

Student: Oh, wait a minute, the lights are supposed to go first.

Student: Wait, now try it. Only that one lights.

Narrator: This is a good point to introduce the term “series circuit.” In a series circuit, all of the components are hooked together in one big circle. There’s only one path for the electricity to flow through. When this circuit is closed, you can see that the bulbs burn very dimly. So the students’ new challenge is to get those bulbs to burn brighter.

Teacher: If you know that that light bulb is good, is there another way you could get more energy into it to have both of them light brightly? Ok. Now what could you do to get more energy to get both of them brightly.

Student: Oh, that… maybe we should move from that.

Teacher: No, you want more energy, how can you get more energy? You’re using one D-cell. What could you possibly do?

Student: Maybe take another D-cell.

Teacher: Alright Theresa, add two D-cells. Do you think that’s an option?

Student: Yeah.

Teacher: Try it.

Student: It works.

Student: Only once.

Student: There is a problem with it.

Student: I told you that the wires snapped. There’s something wrong with the wires. I told you there…

Narrator: This group finds that changing the direction of the batteries makes a difference.

Student: …true calculation. Noow one lights. Watch this, now turn around, and then you turn, let there be light.

Student: …this one around, every one lights.

Student: Oh, the other one lights, too. We’ve done it. It’s a miracle.

Student: This is works.

Narrator: Students can also be challenged to build circuits that run a motor and the light. Or two lights and a motor. How many circuits you build like this, will depend on how much time you have.

The important things for students to remember from this part are that when all the components are hooked together in one big circle, in a circuit, we call that a series circuit. They should also remember that electricity has to flow in one direction. So the D-cells have to be oriented in the same direction.

<Investigation 3, Part 2>
In this part, students are challenged to build parallel circuits in which all the components have a direct pathway to the D-cell.

Here's what you'll need from the kit. You'll need to eight circuit bases, the D-cells, the D-cell holders, the switches, the motors, the bulbs and the holders, and the long and short red wires.

You'll need to make copies of these Duplication Masters: number 15, called "Advanced Connections," and number 16, called "Response Sheet—Circuit Designs." You'll also need your copy of assessment chart for Investigation 3.

Teacher: Yesterday we worked with a series circuit, you had one battery and you tried…

Narrator: Begin by reviewing what the students have learned about series circuits.

Teacher: …trying for a while, some of you went ahead and got two D-cells to make the lights brighter. So now today we're going to come back again, working with one D-cell, and two light bulbs, and your challenge today is, get those two light bulbs burning brightly with one D-cell.

Student: Double it.

Student: Just go like that, and then attach that to the end of the D-cell.

Student: I can't see.

Student: With that, that one doesn't work. It doesn't light brightly. Make it do this.

Student: Yeah, let's try that way.

Student: And then yeah, put in there. Now let's try it.

Student: Hook that in there.

Student: This switch…and then put in there… and then put in there…

Student: What if it doesn't work?

Student: OK, then let's take it apart, and how about, we'll try this…or like this. OK, and that's…cool.

Student: Everything is falling apart.

Student: Maybe it's over here? Let's try this…

Student: OK, it works.

Student: That works.

Narrator: Students draw their diagrams. Reporters draw their diagrams on the board, for students to compare.

This is a good point to have students to generate questions that they can investigate further. If they don't come up with these questions, you might want to add them to the list yourself. You might also want to put some of these questions in the project folder, so that students can investigate them at the end of the module.

The most important thing for students to understand about parallel circuits is that there is more than one pathway for electricity to travel, and each component has a direct pathway to the energy source.

<Investigation 3, Part 3>
Narrator: In this part, students apply what they've learned about circuits to solve a simulated problem for a company that makes strings of decorative lights. The students will think of this as another investigation, but you can use it as a performance assessment.

Here's what you'll need from the kit. You'll need the 8 circuit bases, the D-cells, the bulbs and the holders, the D-cell holders, the switches, and the long and short red wires. You'll need to cut the index cards that you supply into strips like this.

You'll need to make copies of the Duplication Master: number 17, called "Recommendations to the Board." You'll also need your copy of assessment chart for Investigation 3.

Teacher: The people at Lightweight Enterprises had a problem. They needed a string of lights that would not all go off when one light bulb burned out. The boss called her workers together and gave them instructions.

"I want you to assemble two strings of lights for me to look at. Each string should have eight light bulbs. One string of eight should be designed the old way we made them—

when one light burns out, all the rest go off. The second string of light should be designed in a new way, so that when one light burns out, the rest stay on.

So, now our challenge, do you think we could set up the Lightweight Enterprises investigation in our classroom? Could we make two strings of lights, each with eight bulbs and compare how they work?

Student: When one light goes out, all of them go out.

Student: Make sure the batteries are facing the same way.

Narrator: This group has made a large series circuit.

Slipping a piece of index card under a bulb to insulate it from the rest of the circuit, simulates a bulb burning out. In the series circuit, if one bulb goes out, the other bulbs go out, too.

This group has made a parallel circuit using the eight light bulbs.

Student: He did it. Good.

Student: It would probably make the other ones not go out.

Narrator: In the parallel circuit, even if one or more bulbs goes out, the others stay lit.

Student: Interesting.

Student: They're skipping over a light bulb. I thought on a Christmas light if one light broke, then it's good.

Student: Hey, what if one wire come out? Would the entire thing be broken?

Student: Yeah.

Student: Let's see.

Student: Just the ones afterwards would be broken.

Student: See one wire's come out and seeing all the loops.

Narrator: To complete this part, students write a memo to the Board with their recommendations for manufacturing the strings of lights. You'll find a scoring guide in the Assessment folio if you want to use this for assessment.

You'll want be sure that students have a pretty good idea of how electricity flows through a circuit before you move on to the next investigation.

<Investigation 4, Part 1>
Narrator: In this part, students work with electromagnets.

Here's what you'll need from the kit. You'll need the eight circuit bases, D-cells, rivets, one magnet, the long yellow wires, the switches, the cups and small washes, and the short red wires.

For this part, you'll need a copy of assessment sheet for Investigation 4.

Keep in mind that electromagnets can drain the D-cells very quickly. Be sure to remind students that they should keep the switches open, except when they're testing their electromagnets.

To get ready for this part, you'll need to place about 50 small washers—that's about half a container—in each cup for each group.

Teacher: And you know the other day, I was in an old junkyard, and I saw this crane. And the crane was picking up old cars and moving them from one place to another. But then they could turn off the magnetism. It was an on and off thing. When he wanted the magnet to work, it worked, and when he didn't want it to work, it didn't work.

Now what about you? Today the challenge is can you make a magnet that will work when you want it to and will not work when you don't want it to.

Narrator: The getters get their materials and groups begin to tackle the challenge.

Student: Let's try that…to wrap it around.

Student: If you try this part right here.

Student: I'll see how we can do this. Ok.

Student: What do I try?

Student: Try it.

Student: Ok, you should look at it.

Student: No, hook the other side. Like that, so we can put it in place. Now put it over here.

Student: Yeah, put it over here.

Student: We did it. Oh, cool.

Narrator: When all of the students have their electromagnets working, you'll introduce the word electromagnet.

The next challenge for the students is to try wrapping the wire in different ways around the rivet, to find out how they can make the strongest electromagnet.

In this class, the groups have decided to work together and pool their findings to make their decisions. They've agreed that each group will use 40 winds, and they will always use the head of the rivet to lift the washers. But how will they know which is the strongest?

Teacher: How will we know whether Table 1 does more than Table 4? How will we know? Brad?

Student: Because however many washers it picks up, Table 4 maybe picks up more than Table 1. That means that that table probably, their combination probably had a stronger magnetic force than Table 1.

Teacher: Alright, very good. So you have to count the number of washers so you know. Everyone understand what you're going to do? Alright, go for it.

Students (group 1): 21, 22, 23, 24, 25…

Students (group 2): 35, 36, 37, 38, 39, 40.

Student: Unravel that, and see what happens.

Student: Okay, that's perfect.

Student: Okay, here, there, and put it in this one.

Student: Okay, that looks good on our side.

Student: See if it works.

Student: That works.

Student: Let's count now how many washers it picked on one try.

Student: Okay, I'll count them.

Students: 28, 29, 30, 31, 32, 33, 34, 35, 36, 37.

Student: 37 washers. You did 37.

Narrator: The reporters write the number of washers their electromagnets picked up.

Teacher: Now that we've recorded the data, looking at the numbers, which is the best position to wind the wire to have the most effective electromagnet. Scott?

Student: Wrapping it around the first part? Part 1?

Teacher: Alright, and why would that be the best place to do it?

Student: Because it picked up 37 washers and the rest picked up less.

Narrator: The most important ideas for students to take from this part are that they can make an electromagnet by wrapping insulated wire around a rivet and then running current through the wire. They should also know that they can make the strongest electromagnet by wrapping all of the wire around the first section of the rivet.

<Investigation 4, Part 2>
In Part 2, students experiment to find out how the number of winds on the rivet affects the strength of the electromagnet.

Here's what you'll need from the kit. You'll need the eight circuit bases, the D-cells, the rivets, the long yellow wires, the switches, the small washers and cups, and the short red wires.

You'll need to make copies of Duplication Master number 18 called "Winding ElectroMagnets" or have quarter inch graph paper ready for the students to use. You'll also need copies of Duplication Master number 19 called "Reverse Switch." Be sure to have assessment chart for Investigation 4 handy.

Check the batteries by connecting them to a rivet that's been wrapped with wire. If you can't pick up 25 small washers, don't use that battery. Don't throw them away though because they usually can still light a bulb or run a motor.

Plan for making the graph by making a transparency of the student sheet to help guide the student's graphing. Here you'll have two options: You can turn the investigation over to the groups to work independently, or if you'd like to provide a little more instruction, you can have the class work together as you'll see here.

Teacher: But today we're going to try, first of all, with 20 winds, see how many washers you can pick up. Then you're going to do it with 40 winds, how many washers can you pick up? After you've done it with 20 and 40, your group predicts how many you think you could pick up with 30 winds. After you predict, do the 30 winds, pick up the washers, and see if your prediction was correct.

Students: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13.

Student: So 13. 20 winds, 13 washers.

Students: …32, 33, 34, 35, 36, 37, 38, 39, 40. Ok, now we'll see how much we'll do. Brian, do you want to try?

Student: Now bring it over.

Student: 1, 2…27, 28, 29, 30, 31, 32

Student: 31

Student: I got 31. So, um, 31 washers.

Student: 41… it's just the.. opposite.

Student: 41?

Student: 31.

Student: Okay, so it's going to be in the middle of that. What's half of 44?

Student: Half of 44? 22.

Student: And so that would probably be those are in the middle of 13, and 31 is 22, so that would probably be a good estimate for 30 washers.

Student: With 20 winds, we got 22 washers, and with 40 winds we got 44, so with 30, we'll probably get about 33.

Student: You put this inside…

Student: …9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34.

Teacher: On the side here we have the number of washers, so I'm going up to the 20 plus 2, which is 22, and making a dot.

Narrator: After the reporters have shared their data, the teacher introduces the graph as another way to record their data.

Teacher: I'm going up to 40 line, up to 44, so 40 plus 4, and I'm putting a dot there.

Narrator: Some students will be able to use the graph to make other predictions. Ask your students how many washers they think they could lift with 25 winds or 10 winds or 50 winds. You might ask them to predict how many winds they would need to wrap on the rivet to pick up 20 washers or 30 washers.

The important thing for students to remember in this investigation is that the strength of an electromagnet can be changed by the number of winds on the rivet. The more the winds, the stronger the electromagnet. Continue to add student ideas to the project folder.

<Investigation 4, Part 3>
Narrator: In Part 3, students investigate other ways to change the strength of an electromagnet. They brainstorm a list of ideas, and then they set up their own investigations.

Here's what you'll need from the kit. You'll need the eight circuit bases, the D-cells, the rivets, the long yellow wires, switches, small washers and cups, and short red wires. You'll need to supply a variety of different kinds of wire.

You'll need to make copies of Duplication Master number 20, called "ElectroMagnet Investigation." You'll also need your assessment chart for Investigation 4.

This investigation begins by having students generate questions about other ways that they might be able to change the strength of an electromagnet. Some of the questions they generate may be the ones you see on the chart here. Each group will choose a question and plan their own investigation.

You'll need to monitor each group as they plan and carry out their investigation and assess their progress. When the investigations are completed, the reporters will share their group's question and the conclusions. The purpose of this part is to give students the opportunity to apply what they've learned about electromagnets and how to go about investigating their own questions.

<Investigation 5, Part 1>
Narrator: In this investigation, students will apply what they know about circuitry and electromagnets to build a telegraph.

Here's what you'll need from the kit. You'll need the circuit bases, the D-cells and switches, the rivets, the long yellow wires, the short red wires, and the steel strips.

You'll need to make copies of these Duplication Masters—number 21, called "Stream Code," and the assessment chart for Investigation 5.

To get ready, check to D-cells as you did in the last investigation. Also check to pieces of spring steel with a paper clip. If they've become magnetized, you'll need to demagnetize them by throwing them down on a hard surface, or hitting them gently with a hammer.

In this part, you'll discuss communication devices that students are familiar with—televisions, computers, telephones. There's a story in the teacher's guide to help you set the stage.

Teacher: …rapid communication. It wasn't until the invention of the telephone in 1876 that the telegraph began to decline in importance. Alright, now today you have a new challenge, and your challenge is, can you make a telegraph?

On the circuit board, you have the two indentations, that's where you want the rubber washers to rest. This is your new piece of equipment. You're going to stick that inside the arches, close to the head of your rivet, and that will be your new piece. So now your challenge is, make this into a telegraph.

Student: Put it that way.

Student: Put that there and…

Student: How do you know?

Student: We're just testing.

Student: I don't know if this is in, wait. It's not in.

Student: Twist it, so maybe it could stay like in this way.

Student: It's too close.

Student: Just hold it.

Student: We're just testing.

Student: Oh, we got it, we got.

Student: We got it.

Student: Wait here.

Student: Wait because you're just...

Student: Slow down.

Student: Can I play a piano piece on it?

Narrator: As you monitor the students, the circuit should be setup just as it was in the last investigation. Here are the things that you'll want to check if students have trouble getting their telegraphs to work.

First, they should put as many winds around the rivet as they can. Next check the gap, which is the space between the rivet and the steel strip. If it's too big, the strip will not attract. If it's too small, the strip becomes magnetized, and stays stuck to the rivet.

Be sure the students are using a strong D-cell for this activity. They can wire a second cell in series, if they need to have some extra power. The switch should be used like an old fashioned telegraph key, tapping it with your finger and letting it spring back off the bronze strip for each clip. When all the telegraphs are clicking, the students are ready to invent a code to send a message.

Teacher: Each of you has a paper like this on your desk, with the word stream. Now you're going to make up as many words as you can using just those letters in the word "stream." Go for it.

<Students working>

Student: Steam. Your turn.

Narrator: Now students work with the whole alphabet. The students will need practice to send messages successfully.

Student: I can't understand.

Student: E?

Student: Can I take a guess?

Student: One more letter.

Student: Heather

Student: That's my kitty cat.

Student: Heather and Diablo.

Narrator: The important things for students to remember from this part are that a telegraph is an electric communication device, and that a code is a symbolic system for communication. There's a story about Samuel Morse that students will enjoy reading in the FOSS Science Stories.

<Investigation 5, Part 2>
In this part, students hook together two telegraphs, so two groups can communicate back and forth.

Here's what you'll need from the kit. You'll need the circuit boards, the D-cells, and switches, the rivets, long yellow wires, steel strips, short red wires, and you'll need the long 4-meter telegraph wires.

You'll need to make copies of the Duplication Master number 22, called "Long-Distance Telegraph." You'll also need the assessment chart for Investigation 5.

Teacher: You have set up your telegraph boards, and you worked with that. Today the challenge is to send a message from your table to another table. So kind of a long-distance telegraph. For now each table, each pair of tables, will get one set of wires to hook up.

Narrator: The students will dive right in and attempt to set up their telegraphs. They will probably need a few suggestions. Point out the two clips on the circuit base near the blue arches. If they need to connect wires to wires, those clips can be used, instead of twisting wires together.

Student: There's going to have to be some adjusting.

Narrator: So, you can give students help when they need it, here's what to look for. Essentially you have to set up two circuits. Each circuit needs a sender and a receiver.

On this circuit board, I've set up the receiving end. On this circuit board, I've set up the sending end. You should be able to trace the path of electricity through the complete circuit.

Begin at the battery, through the switch, through the long wire, through the electromagnet, back through the long wire, and to the source again.

Then to be able to send a message back, students will hook up a similar circuit, but reverse who is the sender, and who's the receiver.

It looks like a pretty complicated circuit when you look at it like this. But if you think of it as two separate circuits, here's one circuit, and here's the second circuit, and work with them one at a time, you'll find that it is much easier for the students to set up.

Student: This…

Student: This code.

Narrator: In this part, you'll be assessing students' perseverance, as well as their understanding of electric circuits. But the reward is well worth the struggle.

Student: Ready?

Student: No.

Student: Travel all the way to…

Student: Ready? Got it?

Narrator: The important thing for students to remember from this part is that to set up communication between two telegraphs, you have to have two complete circuits.

<Investigation 5, Part 3>
The last part of this module gives students an opportunity to choose their own investigations. You'll need to plan about two weeks to for them to work on the projects at school and at home. This is the time to bring out the project folder. As much as possible, you want students to use their own ideas, and investigate the questions that they have come up with during the module.

If you don't have enough ideas in the project folder for everyone to investigate, you can use the Project Ideas sheet to help students think about more investigations. The project plan sheet should be completed by each student, or team of students doing a project. This sheet helps you control materials and keep tabs on what the students are working on. You will need to decide whether or not you will be able to supply any additional equipment the students ask for. You will also want to make sure that the projects the students propose are realistic, and will be of some benefit to the class.

FOSS suggests students give three minute presentations following the guidelines on the Presentation Guidelines sheet. They can also make a poster to help them explain their investigation to the class. Here's one example of a project built by a forth grade student.

Student: What I made was a lunch-box alarm, and I got the idea from Dr. Henshaw. And when you open it, it makes a loud noise. And what I did was I made a regular circuit inside of the lunch-box. And then I took the string, and attached it to the switch, and put the switch underneath the tab. Then I taped the string up to the roof, so that when you would open it, it would make that noise.

Narrator: The Assessment folio has suggestions for scoring the students' work on the projects. Also in that folio, you will find information in masters for two kinds of summative assessment, an end-of-module test, given in a variety of formats, and suggestions for assembling portfolios.

This is the end of the Magnetism and Electricity Module. Keep in mind that there are details in the teacher's guide that we weren't able to show you the video. Most importantly though I hope you'll enjoy teaching this module as much as I always do.